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INTERNATIONAL SMALL SATELLITE ORGANIZATION
Rick Fleeter, Editor
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INDUSTRY NEWS

Israel lofts third Offeq

Israel launched its most sophisticated small satellite to date on April 5th aboard a Shavit rocket. The 225kg Offeq-3 (which translates to "Horizon-3") utilizes a 3-axis stabilization system to demonstrate an Electro-Optical imaging sensor. The satellite has a dual purpose mission – scientific and technology demonstration. Mission officials plan to assess the Offeq-3 technology for possible use in the Ellipsat program, as well as in the hi-res imaging market. The exact resolution of Offeq-3's sensor has not been disclosed, though it has been reported to be on par with other commercial remote sensing ventures.

Offeq-3 represents a major achievement for the Israelis who built the satellite almost entirely with their own technology. The spacecraft boasts fully redundant systems with components that (except for the horizon sensor) were manufactured in Israel. To date the satellite has performed at or above expectations.

Pegasus returns to flight with three MicroStars

Orbital Sciences Corporation returned to flight on April 3rd with the launch of a standard Pegasus rocket from the company's customized L-1011 jet, which took off from Vandenberg AFB, and dropped the Pegasus over the Pacific. Three small satellites, ORBCOMM FM1 & FM2, and MicroLab-1, were released into 730km x 750km x 70° inclination orbits. The two ORBCOMMs use Orbital's MicroStar bus: a 40 kilogram disc, about 1 meter in diameter. The MicroLab spacecraft is similar in design, but is thicker and weighs about 68 kilograms.

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Forging a STEDI path toward a new paradigm for space missions...

BU's TERRIERS and CU's SNOE

...an in depth report by Joshua Cohen and Todd Mosher

The University of Colorado and Boston University must feel a little like Yogi Berra when he said, "It's deja vu all over again."

On October 4, 1993, Tom Woods, Stan Solomon, Scott Bailey, Charles Barth and Rick Kohnert from the University of Colorado and Supriya Chakrabarti, Dan Cotton, and Jim Vickers from Boston University were all perspiring together in White Sands, New Mexico awaiting the launch of two sounding rockets. NASA rocket 36.107 and NASA rocket 33.062 were launched an hour apart carrying various instruments to study the Earth's atmosphere. Following a dinner at the local Mexican restaurant, La Hacienda, in Las Cruces, NM, this group of atmospheric scientists never would have dreamed they would be reunited to prove that credible science can be done on low-cost spacecraft.

Yet just over 16 months later, on February 17, 1995, the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) and Boston University's Center for Space Physics were named the two winners in the Phase I Student Explorer Demonstration Initiative (STEDI) program administered by the Universities Space Research Association (USRA) for NASA. With Barth and Cotton named as the respective principal investigators on the two projects, and the rest of the White Sands group serving various other roles, they will again sweat out another couple of launches together.

Those launches are expected to come in early 1997, after an intense two year spacecraft development, fabrication, and testing phase. The method by which the order of launches was selected is emblematic of the no-nonsense attitude that USRA and the STEDI management team has taken towards getting things done quickly and efficiently.

In a recent teleconference between Barth, Cotton and Jack Sevier, the USRA program manager, the sticky issue of who launches first was decided. Rather than the long drawn out discussion that you might expect, the conversation went something like this:

"OK, I've got the coin on my end. Dan, you call it."
"Heads."
"Heads is called... it came up tails."

And so it was decided that the University of Colorado would take the first launch, and Boston University would get the second launch, a month later.

But this simplistic decision making process does not characterize the challenge that these two projects face. Two years from now the University of Colorado is expected to launch the Student Nitric Oxide Explorer (SNOE), while Boston University prepares its Tomographic Ex-

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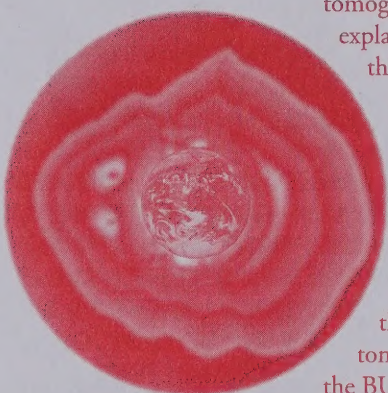


This simulated picture of the Earth's ionosphere shows the various levels that TERRIERS aims to study in detail.

periment using Radiative Recombinative Ionospheric EUV and Radio Sources (TERRIERS) satellite for flight. Each project is expected to be completed for under $4.4 million, including one year of mission operations. It is hoped that they both will verify the efficiency of smaller, lower-cost space flight missions.

Down to a Science

"The scientific community is convinced that there are important scientific problems that can be attacked by small, low-cost spacecraft," noted Barth, as he explained the specifics of the SNOE science mission.

SNOE plans to study how variations in solar soft X-radiation and auroral activity in the polar regions affect the nitric oxide density in the Earth's atmosphere. Nitric oxide plays a critical role in the chemistry of the Earth's fragile ozone layer.

The SNOE spacecraft's principal instrument will be an ultraviolet spectrometer to measure nitric oxide in the lower thermosphere portion of the atmosphere. It also will carry an X-ray photometer aimed at the sun and an ultraviolet photometer aimed at auroral activity near the Earth's poles to measure solar photons and auroral particles which have been linked to nitric oxide fluctuations.

As the first word of the acronym suggests, TERRIERS mission objectives are based largely on tomography, which can be a difficult process to explain, especially when it's being applied to something as amorphous as the Earth's ionosphere. So Cotton likes to use the analogy with CAT scans, which are well known for their common use in the medical profession. "The CAT scan gave medical researchers a new way to look inside the body," explains Cotton. "In a similar manner, TERRIERS will give us a new picture of what is happening in the Ionosphere." Both processes are based on tomography, in fact many of the techniques that the BU team is using for data analysis are evolved from medical research.

Results of TERRIERS research will have applications in the field of "space weather". Occasional storms of high energy particles can have dramatic effects on the ionosphere, disrupting radio communications, and sometimes even knocking out power girds in the higher latitudes. But TERRIERS is primarily an exploratory mission. "This is basic enabling research," says Cotton. "TERRIERS is a comprehensive package for studying the ionosphere, its interaction with the upper atmosphere, and the Sun which of course is providing the input that drives all the phenomena that we will observe. To do all of this on one spacecraft for such a low cost is unprecedented."

Only a few months ago the two teams would have been considered arch rivals. But with science missions focused on similar regions of the Earth's atmosphere, the two teams now have the opportunity to cooperate. "Never in my wildest dreams did I think that both these missions would be selected," said SNOE Deputy Principal Investigator Solomon. "We have fairly similar science goals and have already made plans for science collaboration. They are very complementary missions. The sum of the parts may be greater than the whole."

Low Cost by Design

Perhaps more than any other space research program, the competition on STEDI drove the teams to demand more results for less money. Engineering an exciting, reliable science mission to live within the program's $4.4M cost constraint is quite a challenge.

The TERRIERS team used a number of cost saving strategies to help meet the challenge. "On the technical side, we are able to save a lot by relying on AeroAstro's experience in building low cost scientific spacecraft." Cotton explained that by using components for which the development effort is largely complete, AeroAstro is able to deliver a robust spacecraft at very low cost. AeroAstro will also provide use of its tracking ground station, located at its headquarters in Herndon, VA, under a lease to BU. This saves the program from absorbing the high cost of building a dedicated ground station at the mission operations center.

Another big cost saver was streamlining management. "We have a small team doing a large amount of work and getting lots of help from students." But perhaps the most important cost saving measure was the realization that not every decision could be made using a "science rules" attitude. "We have a detailed de-scope plan," says Cotton, "and will not hesitate to narrow our science objectives if it is necessary for a successful mission."

The Colorado team found that they needed to make similar sacrifices in order to keep the mission under the STEDI cost cap. "Our fundamental approach to meeting the budget has been to constrain the data rate," said Solomon. "Through constraining the data rate, even when we wanted more, we found that the rest of the spacecraft stayed at an affordable level."

SNOE is also using a high degree of in-house fabrication using student labor to keep costs down. They also developed a simple check book style of

accounting that would allow them to take a quick look at their cost progress and to make it easier to spot problems.

"The big challenge in meeting this program is the cost," said Solomon, expressing the thoughts of all the individuals involved as well as the program's many observers. "This requires innovative strategies."

Education is Paramount

In the case of STEDI, innovative strategies are synonymous with student involvement. This includes both graduate and undergraduate students studying at the two universities. In fact the two year schedule of the program is designed around that of a student's academic term.

"In order to get students involved we've got to have quick turnaround flights because students aren't around that long," explains USRA President Dr. Paul Coleman. "This quick turnaround is just as important for companies, so that their entry level professionals can get this kind of experience without tying them up on the project for more than a year or two."

On TERRIERS, students have been involved with the drawings, scheduling, and modeling of the spacecraft in the proposal and in Phase I. In Phase II, they will help with the integration and assembly, as well as train for the mission operations after launch. PI Cotton says he has already seen the students "blossom into integral team members" on the project. Cotton's example of this was senior astronomy and physics major Valerie Taylor, who has been with the project since early in the proposal process. "Valerie has done a large portion of the payload drawings," said Cotton, "and on the last night when I had get some sleep before the review, she took charge of getting everything put together. I was a little nervous, but she got everything done."

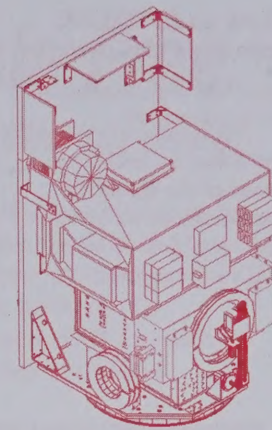
The Colorado team plans to employ low-cost student labor to help fabricate the satellite and instruments at the LASP Space Technology Building in CU's Research Park. There are also plans to continue with an associated class that has been taught for the last year in the aerospace engineering department. "We have a carefully crafted plan for student involvement," said Solomon. "Each student is assigned to a spacecraft or instrument subsystem and works in partnership with a LASP engineer."

Students will also benefit from other local groups that are involved with the project. Scientists from the National Center for Atmospheric Research are collaborating on the solar measurements, while engineers and retirees from Ball Aerospace will transfer expertise back to the university by teaching classes and as advisors to the students. "We have Ball professional engineers working directly with students both in a classroom and a laboratory environment," explained Barth. "We are transferring the knowledge of Ball back into the university."

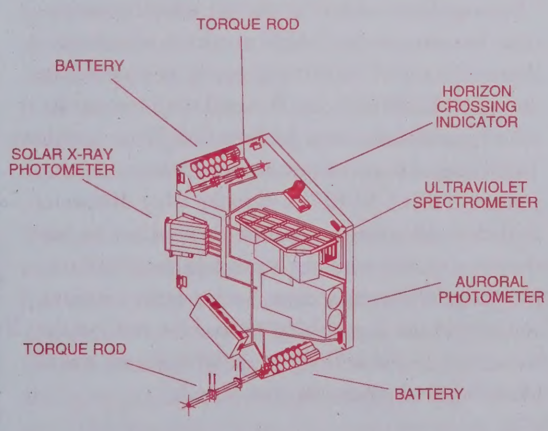
But neither project has stopped at just university students. Both projects have also found innovative ways to get high school students involved.

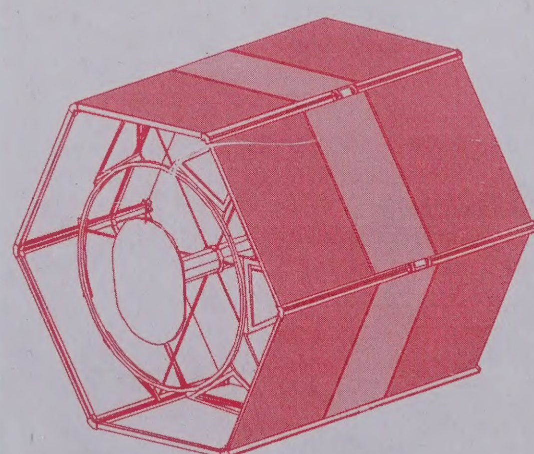
For TERRIERS, they are employing the rather unusual idea of flying an entire payload box built by students at Cleveland Heights High School. The brainstorm came in the middle of writing the initial proposal, when it became clear there would be an empty slot in the satellite bus. This prompted Rick Fleeter, president of AeroAstro, to contact his high school alma mater and see about having them build an experiment box to fill the gap. "The kids are very excited about this opportunity to fly real space hardware," says Fleeter. "They've been working very hard on testing their payload, a micro-accelerometer, and a Lyman alpha sensor."

On SNOE, they are collaborating with a local Arapahoe High School CAD class. In essence the high school is serving as their drafters, preparing many of the mechanical layout drawings and interface documents of the spacecraft. "It is way past what you normally expect," said Solomon. "It is



An isometric view of the TERRIERS satellite shows the payload sitting just in front of a solar panel and on top of the spacecraft bus electronics. Several patch antennas are visible, mounted near the top of the solar panel with brackets. TERRIERS' torque coils are also easily recognizeable on the front and side of the bus.





The SNOE spacecraft (left) will house many of its components on a base plate (far left).

Check out the TERRIERS page on the ISSO web site:

http://www.isso.org/feature/terriers/terriers.html

You'll find a QuickTime movie of the TERRIERS spacecraft, as well as a number of links to more STEDI information.

not often that high school students get to help build a spacecraft."

The Task Ahead

"When we won this project, I was pretty excited," said George Stafford, a CU graduate student working on SNOE. "After 20 minutes of jubilation, I realized we were going to have to build it. Then I was a little worried. Building a satellite is no small task. With the money we are getting, we are tackling quite a project."

Echoing Stafford's sentiments, Cotton's immediate reaction was a mix of emotions. "Of course I am ecstatic, but at the same time, I'm a little anxious, having already gotten a little taste of how difficult this project will be."

Cotton is referring to Phase I of the STEDI project in which six teams went through four months of intense design. Each team sought to define and analyze the finest details of their mission, in preparation for the exacting standards of the USRA review panel. The down-select review has come and gone, but the pressure is still on the two winning teams. Because now they have to prove themselves to an even more exacting standard... reality. Building satellites of TERRIERS' and SNOE's complexity at such a low cost is a difficult job indeed — one that has traditionally been done with more people, more time, and more money. But the team leaders are confident that they can deliver.

"The schedule is tight," explains Bob Dill, AeroAstro's program manager for the TERRIERS spacecraft. "However, there are no technical problems that will keep us from meeting it — I'm confident of that. The real challenge is the budget, which leaves no room for major mistakes. But we can do this... If I didn't think so, I wouldn't be on the project."

The Boston University team poses with a full scale model of the TERRIERS satellite. Professor Supriya Chakrabarti is standing in the foreground, just to the right of the model.

BOSTON UNIVERSITY PHOTO SERVICES

"There may have been many factors that led us to be one of the two teams selected," said Solomon. "But the decisive one was probably the experience and reputation of our team, particularly of its leader, Professor Charles Barth. At LASP, we are confident that we can do this mission."

A New Paradigm?

USRA's Coleman hopes that if STEDI successfully demonstrates the efficiency of small missions that this program could blossom into 25-30 small low-cost missions launched every year. He would like to see these small missions used for technology development and Mission to Planet Earth. "STEDI is university based, and research oriented," said Coleman. "What I think industry is going to do is find all kinds of other uses for capabilities in this mass range."

As well as serving as a potential source for growth in the small spacecraft industry, education value is a cornerstone of the STEDI philosophy. While it is unlikely that every university will have a couple of satellites in orbit around the Earth, USRA does hope that this program will allow more students to enjoy the thrill of space flight. "We think that there is a reservoir out there of students who are still excited about the space age," said Solomon. "They just haven't had the opportunity to be directly involved. We want people who want hands-on experience and the chance to do something real and exciting."

In some ways, STEDI is simply the latest manifestation of a paradigm shift away from the typical space program, which was usually a conservative, broad-focus, long and drawn out affair. More often than not, new programs are managed aggressively, focusing lower cost, quick-response efforts around a narrow set of goals. Prof. Chakrabarti of BU's Center for Space Physics seemed to sum things up the best:

"The capability of our spacecraft is easily comparable to some of the SMEX missions, which are about a factor of 10 times as costly as what we are doing. TERRIERS also fits well with one of the stated goals of the New Millennium Project, to have 'highly capable and autonomous spacecraft'. In general, I think STEDI will make a big difference in future missions, and we are very excited to have the opportunity to make a positive contribution. However, at the same time, we are quite cautious since everyone is watching to see how well we do. If we are successful with this type of mission, it will likely become a mainstay for NASA."

..."News", from page 1

Both ORBCOMM satellites are experiencing technical problems which surfaced within a few days of launch. According to Orbital, most of the spacecraft subsystem checked out as expected. The problems have come in the gateway communications subsystem and the subscriber communications subsystem. At press time, Orbital announced that they had reestablished communications with the second Flight Model (FM2) satellite. The contact took place on Saturday, May 13, when the satellite completed a self initiated "reset procedure" that cleared a processor which had previously blocked communication. New code was uploaded to prevent future recurrences of the problem. Orbital is optimistic about rescuing FM1, and remains committed to completing the 26 satellite ORBCOMM network. If all goes well, Orbital plans to use these first two satellites to begin providing commercial store-and-forward communications to customers worldwide.

Things have been much smoother for MicroLab-1 which has provided some promising early results from the science experiments on board. An Optical Transient Detector (OTD) sensor, provided by NASA's Marshall Space Flight Center, has proven its ability to detect momentary changes in light intensity. This capability is used to study cloud-to-cloud and cloud-to-ground lightning. A second sensor has been observing global atmospheric "soundings", including parameters such as temperature, density, moisture and pressure. This GPS/Meteorological sensor, supplied by the University Corporation for Atmospheric Research (UCAR) and the National Science Foundation (NSF), utilizes radio occultation, a method which observes GPS satellites as they appear to set below the horizon. As the ray path cuts down below the atmosphere it is bent and refracted, and atmospheric temperature readings can be deduced as a function of altitude. In certain respects, these temperature soundings are better than any others. For example, the vertical resolution accuracy is quite high, and matches radiosonde soundings very closely. Radiosonde is the primary source of data for weather forecasting to-

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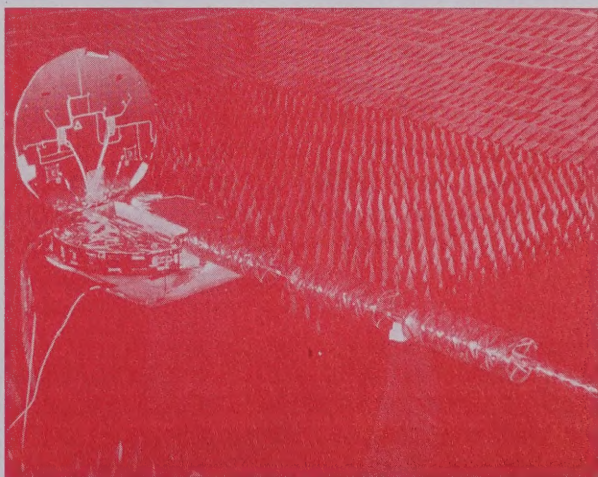
Data from the GPS/Met experiment is available on the World-Wide Web:

http://pocc.gpsmet.ucar.edu/



A flight model of the ORBCOMM satellite undergoes anechoic chamber tests.

ISSO Guest Column

Phoenix – the Virtual Corporation

by James Schoonmaker

Phoenix is an early stage business startup specifically designed to enable aerospace customers to field state-of-the-art products in a manner which is better, faster, and cheaper than existing aerospace corporate models. In order to facilitate the creation of this innovative company, the founders of Phoenix are requesting feedback on the concept, potential proposals, and names and backgrounds of aerospace experts willing to participate in making Phoenix a reality. This article briefly discusses the need for a new way of doing "aerospace business" and then describes the mechanics of how a company such as Phoenix operates.

This article was composed by James Schoonmaker and edited by Scott M. Johnson.

As many of you well know, the aerospace industry within this country is struggling to maintain its world preeminence. Countries such as Japan, China, and France have made great strides into this market, generally at the expense of the American aerospace industry. Additionally, defense and NASA budgets face increasing pressure from Congress and the American people, making it even more difficult to survive. Consequently, the domestic aerospace industry must adopt a new aerospace paradigm based on value, customer service, and speed.

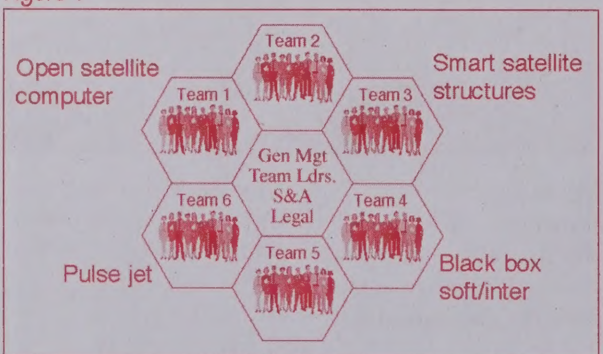
Organizations such as the ISSO serve to promote the migration from large, complex, and expensive space hardware to smaller more reasonable and more effective projects. These small satellites provide excellent value for the space investment dollar for both the government and commercial customer. We at Phoenix applaud the efforts of the ISSO in this regard. However we also feel that the current industry paradigm is insufficient to bring this vision to reality. In response to this concern we have developed a business concept which could provide the necessary mechanism for bringing affordability and access to the aerospace market.

There are currently two types of aerospace companies in the market today. First there are the familiar large aerospace prime contractors who develop large complex products with huge budgets and long development times. These companies, in spite of attempting to reinvent themselves, remain too big, too rigid, too costly, and too slow.

The second industrial context is the small start up companies spawned by the popular Small Business Innovation Research (SBIR) grants. Although many of these companies have become very successful, the growth of these companies with respect to the market size has been limited by typical business start up risk and high barriers to entry. These companies are usually undercapitalized, managed by product focused engineers, and are often forced to bet the success of the company on one project or product. Consequently, many aerospace start-ups fail to mature into full fledged industrial competitors.

Internal Structure
Development teams supported by experienced management, sales, marketing, and legal staff of Phoenix.

Figure 1



Phoenix founders thus determined that if an aerospace company could be designed around the following tenets it would have significant competitive advantage:

- The business must have flexibility and adaptability as its core strength
- It must have big business revenues with small business incentives
- It must utilize the latest in information technology to permit the real time flow of information across all business functions
- Non value added functions must be eliminated
- The business must recognize and leverage the mutual interdependence of all business functions

All of these tenets combine to enable this company to develop products for half the cost and development time as typical competitors in the industry. The results of this process yielded a radical new business concept - Phoenix.

Phoenix Business Model

Phoenix in its truest form is a project/product incubator which develops products from conceptual "lab proven" technologies to a point where market viability is assured. This is typically the riskiest part of the development process and one which every business start up must endure. Phoenix deals with this type of risk directly by applying business and technical expertise within an infrastructure which supports several development projects concurrently.

This model offers inventors, entrepreneurs, and technologists several advantages over current technology transfer methods (i.e. sale/licensing/new venture creation)

- Offers proposal originator(s) and support team members substantial equity interest for remaining highly motivated
- Removes typical business start-up costs
- Spreads ongoing overhead costs across several projects
- Enables knowledge share between projects
- Relies on established business and management competency in product development and project management

Structure

Phoenix consists of an organizational infrastructure which supports several virtual product development teams. (See Figure 1) Each of these teams are made up of industry, government, and academic professionals who have demonstrated expertise required by the particular development project. These predominantly technical professionals will develop the

product in a manner and environment very similar to that of a business start-up. The teams will have control and responsibility for the design, development, and manufacture of the prototypes and finished hardware. However they will also draw upon the supporting infrastructure of Phoenix which provides the remaining resources outside the specific product development effort.

The following functions are performed by the Phoenix infrastructure:

- Information technology
- General management
- Human resources
- Sales
- Marketing
- Product development managers
- Financing if not provided by the proposal writer

Several things make this business model unique:

- All of the innovations will be invented externally within academic, industrial, or governmental research
- Project teams will be hired only for the duration of the project thereby limiting fixed costs (virtual?)
- All project team members will be given substantial equity/profit sharing incentives (comparable to that in a venture funded start-up)

The following steps best illustrate the process by which Phoenix operates. (See Figure 2)

Step 1. Proposed technologies, products or projects are sent to Phoenix for evaluation
Step 2. Phoenix management along with a panel of experts from industry and academia evaluate proposals based on business profitability, credibility of the proposal writers, market potential etc.
Step 3. Promising proposals are then sent out to a database of experts maintained by Phoenix. In addition to the proposals a list of expertise requirements for the development team is attached. Experts evaluate proposals and select any for which they are qualified and have significant interest.
Step 4. Phoenix then evaluates the strength of the proposal as well as the potential development team and decides whether to accept the project. (original proposal writers will be included in the development team as well if desired)
Step 5. Accepted proposals are matched with a project team leader from Phoenix who is highly skilled in managing disparate groups within this type of organizational framework and environment. Venture capital agreements are developed if required and profit sharing incentives are negotiated with each team member.
Step 6. Team sets out to develop the technology, product, or project within the budget and time frame specified by the agreed upon proposal.

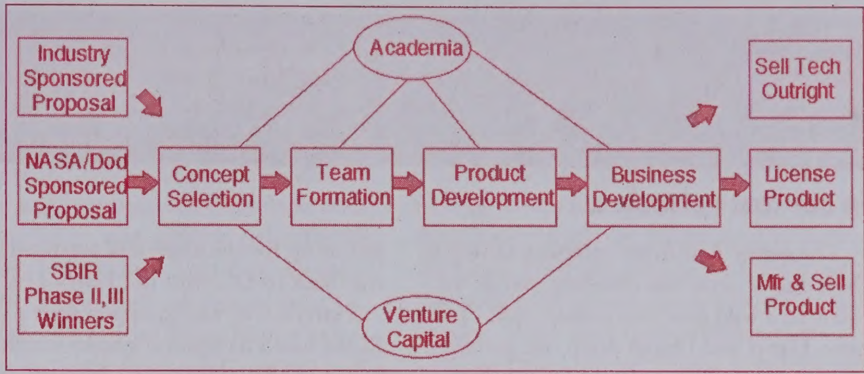


Figure 2

Phoenix Business Cycle
Process diagram of Phoenix product and business development cycles.

Step 7. Once product development is in progress, market and business development activities finalize the profit and market potential as well as the appropriate business strategy.
Step 8. Once the development of the product and business are completed a decision is made by Phoenix, the teams, and possibly venture capitalists to determine the future of the product or technology. At this point a decision is made as to whether the technology or product should be sold outright, licensed to a third party, or spun off as a separate business unit for the manufacture, sale and support of the technology or product over the long term.
Step 9. Team members return to their earlier organizations, seek greener pastures elsewhere, or apply to be a part of another development team. In the event that a business is spun off, many of the team members may wish to join that business. **Regardless of the business strategy, all team members will continue to receive their profit sharing bonus for as long as the product or technology generates revenues.**

Current and Future Role of Phoenix

Our initial focus is on small stand alone products which can be developed by a group of 8-15 team members within the Phoenix infrastructure. These projects will have a duration of six months to two years and we envision approximately three to five simultaneous product development efforts at one time. However as Phoenix evolves we fully expect to participate as a significant player within this industry.

You can view feedback on this story or leave some of your own by checking the online version of the article. The ISSO Newsletter's online address is:

http://www.isso.org/publications/newsletter/newsindex.html

What do we need from you?

Still very much in its infancy, Phoenix has begun developing relationships with major academic research institutions, the venture capital community and the industrial and governmental community at large. However we are currently accepting proposals (executive summary length) as well as feedback regarding the business concept. Additionally, we have begun building the expert data base and would welcome anyone who would wish to enter their name, address and phone number and a brief explanation of your background and expertise into the data base. Feedback can be provided via e-mail at jschoonm@mit.edu, or you can contact us via the ISSO home page on the world wide web (http://www.isso.org).

A Wrinkle in MicroSpace

PART 2

BY RICK FLEETER

In our last episode...

The sunny AeroAstro company outing to the Virginia caves was clouding over as we followed a wild goat into a deep cave. Jennifer, Har'el and I faced death, we got dirty, and we popped out some other end of the cave, to be found by Hilary and Gib, a farming couple in the Virginia Blue Ridge. They fed us and let us use their phone, the latter to no avail other than to reach Jennifer's father, a neat trick since he had died years ago having broken an ankle out fishing on a cold Vermont winter's day. As if this weren't amazing enough, they told us stories of small satellites and the services they receive from them, including weather, email, pollution policing and customized news. Since we couldn't reach anyone back in Herndon or Reston and it was a long drive back, they put us up for the night and arranged our ride back to DC with Dr. Harry Lee.

Harry's VW was equipped with a CD-ROM based navigation system which he was happy to show off for us. It was disquieting that the area we had driven to the day before via a maze of unimproved roads showed on his CD map as a rather large airport – and displayed no trace of our route to the cave nor the small lot where our cars had been parked. Not only were our memories and experiences at odds with the CD-ROM, but also with Dr. Lee, who spent his career in federal airport work and knew that site intimately. Thanks to a dense network of small, LEO satellites, the entire US, and most of the forested world, is under constant surveillance for incipient forest fires. Airports like this one dispatch water-dropping planes to nascent fires and extinguish them so quickly that the US Department of the Interior has discharged from duty all of its crews who used to risk their lives parachuting and four-wheeling into forest fires to fight them after they had already become full-grown monsters. What a totally sensible use for LEO satellites, I was thinking. The sensors, satellites and forest fires all exist in our world, but no such system. Why?

Rather than ply Harry with philosophical questions about our problems – those of a world he knows nothing about, I asked him about his career in the government.

"So you worked for the FAA?"

"Do I look that old? Yeh, I worked for FAA back when they called it that – must be almost 25 years now since we changed."

...now, on with the story!

The letters FAA being printed prominently on my commercial pilot's license, I was about to ask the obvious question when a loud beeper went off and a yellow arrow light pointing forward flashed on the dash. Harry slowed down and moved to the right, staring out the windshield.

"Were you speeding?" I asked.

Just then an oncoming car – a red pickup truck, really – popped into view over the hill in front of us. He was also squeezed to the right but even so it was tight passing on that tiny old road.

"What was that all about? How did that work?"

"Collision avoidance. We started it for the airliners but Transportation picked it up. It'll be mandatory next year, but most new cars already have it."

"Yeh, but how does it work?" I tried not to seem too naive.

"It's pretty simple. Each car has a low power spread spectrum transponder. A ranging system that one of the small satellite companies invented, originally to get their satellites' ephemeris, repeatedly measures range and calculates closing rates to nearby cars. If a small on-board laser radar doesn't see a target – like if it's over a hill – the alarm goes off. In heavy traffic it shuts off. But even limited to just rural and light traffic situations, it has really cut down on accidents out on the open road."

"Neat," I said, trying not to sound too surprised. "So what happened to the FAA?"

I look pretty young for 41 and Harry probably took me for young enough to not really remember Vietnam. He patiently explained that by 1971, '72, Nixon was taking plenty of heat over the cost of the war. Mean time, NASA was experiencing a crisis in identity in the letdown following Apollo. Young people were angry about the military industrial complex. Nixon addressed all these problems in one simple stroke of the pen. He folded NASA into the FAA creating FASA – the Federal Aviation and Space Administration.

"Military people liked it since they didn't like civilian space anyway. To space enthusiasts Nixon had two answers: that space would get supported within the new agency; and that it would grow into a huge enterprise – just like commercial aviation. To the general public what he offered was the promise of a grand space program with virtually no tax dollars. What happened in fact is the exodus from the old NASA just accelerated and by the time the merger was completed, FASA employed only a couple thousand space people."

Clearly Harry liked to talk, and we were all absorbing every word of this apparently fractured version of modern American aerospace history. "For a few years virtually nothing happened in space. It would have been a scandal except the world was preoccupied with Watergate, Vietnam, double digit inflation, $1 per gallon gasoline and wage and price controls. Space was interesting, but in those days it was labeled irrelevant, which to the average person it really was."

"Nobody launched anything?"

"Oh it wasn't that bad. The geosynchronous communications business did just fine – it seemed to thrive under FASA. Scientists and experimenters were in bad shape though. To get in space at all, researchers used funding from NSF or wherever and built their own little satellites in their own labs. They found piggyback space on commercial and some military launches."

"For a few years nothing seemed to be happening in the US space program and there was a lot of controversy. Of course the Russians were scoring plenty of propaganda points with their crews on orbit. People in America, Europe, around the world really, believed America had given over the space initiative to the Russians. Some even said this proved that a capitalist society must ultimately degenerate by the forces of greed. As if to prove they did not suffer the same malaise, the Soviets, Europeans, Japanese and Chinese all accelerated their piloted space programs. Many of our space leaders from Gemini and Apollo left to support these vigorous foreign programs. But with Ford struggling to get the country under control, space still did not get much attention."

"So what was the FAA doing all this time?" I interrupted. Harry loved to talk, and I was glad to encourage him.

"FASA," he corrected me. "Not much different than ever. You gotta remember the old FAA was well over 50,000 people, and adding a couple thousand space guys didn't get much notice. The ex-NASA people were kept busy designing a national space regulatory system. It was built to exactly mirror the air transport system."

"I mean, they established flight corridors for rocket launches, uniform construction and qualification standards for rockets and satellites and even a licensing system for satellite operators like our pilot licenses. It was all very theoretical since basically... well, ok, we actually had nobody to regulate, no "spaceports" to operate, but we did have the world's most progressive commercial style space traffic control system. Government waste at its finest, I guess."

"But the license structure turned out to be pretty useful. Rather than concede control of radio spectrum to the FCC, these guys allocated NASA's old blocks of frequencies to something called Space Services. If you passed tests in technical competency, you were basically licensed to own & operate satellites according to FASA rules. Spread spectrum was the law, and no broadcasting was allowed – that remained, as it had been, FCC's turf. Other than that, anybody could pass a series of standard tests and go off and build and launch rockets and satellites and communicate with them point to point – for private, commercial, scientific, educational or whatever uses they wanted. We figure people don't ask you on your flight plan *why* you are flying from a to b using the national air transport system – or whether you are driving down the freeway for business or pleasure. You pay your taxes, you pass the test, you have earned the right to use the highways, or the air routes, or in this case, the airwaves to talk with your satellites."

Harry then interrupted himself to ask if I was finished with the map display, which I was. He zoomed out to show the region from where we were all the way to DC then punched a button labeled Traffic. All the major routes displayed, after a few seconds' delay, in colors, and a key on the display showed red meant under 10 miles per hour, orange is 10 to 25, blue 25 to 40 and green indicated average traffic speeds over 40.

"I suppose you'll want to know how that works too," he chided. "Didn't you say you ran a satellite company?"

Luckily he didn't wait for my defense and just went on yakking. "Cheap Doppler sensors along the roadsides – a few of them per mile each direction. Probably 5 or 10 thousand of them cover the DC area. A little satellite comes over the horizon, reads and stores all the speeds those sensors see on the road. When I hit that 'traffic' button, the satellite downloads to me all the data relevant to the map on my display – and charges my account $1. The DC franchise is getting about a half million hits a day. Nation wide it's a $4 billion a year operation. They are talking about Europe and Asia. I guess traffic is even worse there than here. But like all these things – fire detection, pollution monitors, weather forecasts, wireless newspapers, even simple stuff like night time illumination for police work, search and rescue and emergency crop harvest, those guys are still too bulloxed up in licensing issues. It's really a shame since all these low earth orbit systems are inherently global anyway. Right now these satellites only work over the US, and I guess spend the rest of their orbits charging their batteries."

"What really bugs me is these other countries' bureaucracies are costing their citizens hundreds of lives a year. Just the most basic stuff. Like these personal emergency transmitters... Harry took a pretty standard issue black Casio digital watch off his wrist and handed it to me. The Japanese sell millions of these every year. Just hit the red button 3 times within one second, wait for the screen prompt then hold down the button for 2 full seconds and you'll be geolocated by satellite to within a few hundred feet and a rescue team will be there inside of a few minutes anywhere in North America."

Jennifer's father, I thought. That's how they rescued him. In this world, an outdoorsy guy would surely have one of those watches – probably Jennifer's mom would have given it to him. When he twisted his leg in the snow, he just pressed the button and they picked him up. Nothing remarkable. In our world, he had frozen to death...

Harry went on. "The company providing that service is getting a $10 premium per watch and over 200 million have been sold. It's a big money maker, but it's saving over a thousand lives every year. Simple technology and Casio and Swatch are making them by the boatload. But their own people can't use 'em 'cause of outdated and bureaucratic uses of satellites and radio spectrum."

"So Harry," I was now getting adventurous, "what about the space shuttle and space station?"

"What about them? Russia built them – with a lot of help from the French. Oh the French were so intent on moving in to the so-called vacuum left by the US. Can you the believe at one point the French, Chinese and Japanese government annual space budgets were each above $10 billion? Russia's alone was over $20 billion. We used to call

them the Space Axis." Harry smiled. "Meanwhile in the US we had just a skeleton regulatory staff at FASA. The Axis had grandiose plans to inhabit LEO, the moon and ultimately the planets. And I'll tell you, a lot of Americans wanted it too. Mondale got elected in '76 partly by promising US dominance of space like we had under Kennedy and Johnson. And economic times were tough when the war ended. We were in the doldrums while the Axis economies were enjoying a space fueled boom. No way would congress give Mondale the billions he wanted – how could we compete with the $50 billion per year being spent by the Axis."

"All this time we were doing a little space work at FASA – mostly giving out very low level operator permits for scientists. But in the early '80s things began to change. The Axis was finding that their eyes and their ambitions had exceeded their means. The bigger their budgets, the more everything seemed to cost. Meanwhile, we started seeing a lot more permit applications. Some small companies started making money carrying messages and doing geo-location – tracking equipment and cargo. Pretty soon, we're processing several hundred satellites a year doing all kinds of stuff – mainly weather, traffic, news, environmental stuff like forest fire alerts and enforcing EPA rules. But there are lots of little niches. Companies put up little satellites to prospect for gas, oil and minerals using proprietary sensors. And this company doing search and rescue from your digital watch is really growing fast now."

"And there is no government space?" I knew the answer, but I had to ask.

"Oh, there's lots of government space – just no government space agency. You've got the Air Force doing GPS and all kinds of stuff. Interior Department is handling forest fires and resource management. As a country we are really active in space but it's always just a tool, not an end in itself. US space revenues are running $20 or $30 billion per year – with almost no taxpayer expense. The Axis has spent half a trillion dollars and every year they feel they have to ante up more money. Crazy... Well, that's how those countries work, I guess. Americans would never go for that kind of socialist thing – government meddling in industry like that."

By now we were getting towards the DC metro area. A sign said we were 29 miles from Leesburg, so we were maybe 50 minutes to our office. Looking over at Har'el and Jennifer, I think we all knew we weren't in Kansas anymore, so to speak. While Harry was rambling on about the '70s and '80s, assuming we young Turks were wanting for historical perspective, which under the peculiar circumstances we very much were, I had been cruising his CD-ROM map looking at Herndon and Reston. Just as the parking area and small roads leading to our company outing site were displaced by that new airport, few of the side streets near our office or my house, which is in a relatively new part of town, were on the map. The big roads were all familiar but in place of the small ones I knew were lots of similar little streets I didn't recognize. The three of us needed to huddle.

"Harry, any place to pull over around here for a pit stop?"

"Excellent idea! There's lots of little places out this way."

Within 5 minutes we stopped at one. While Harry used the single toilet, we strategized. Har'el pointed out that Harry's rendition of history basically diverged from ours 25 years ago. "Rick, we are in a different world. One just like ours, but something happened around 1970, and it went down a different path. The older streets and towns and landmarks are all the same, but a lot of new stuff turned out different."

"Very different. Jennifer, I bet your dad was saved with one of those emergency locator watches."

"That would be pretty incredible," Jennifer changed the subject. "I agree with Har'el. But I bet there's no AeroAstro around here. This world is filled with small satellites – there would have been no reason to start AeroAstro."

What a depressing thought! I had borrowed a phone book from the clerk. Jennifer was right. Neither AeroAstro nor Rick Fleeter were in there. My brother, Tom, was in there – or at least his office was. Well, Tom wanted to be an MD since he was 6 or 7 years old back in the '50s. That hadn't changed, and I guess he still did his residency in DC and stayed here. Tom's life was always a bit more directed than mine. The different course of history since the early '70s when I started college must have sent me in a completely different direction.

Jennifer suggested we head to Tom's office. Where else could we go?

Harry walked up – "you kids ready to go?" And we got back in the car and headed for Reston.

"Since we've been missing, our families are probably worried. We thought it might be better to stop at my brothers office." I told Harry the address I had memorized from the phone book. "Hey, will this thing route us to his office?"

Harry was pleased to show off the CD-ROM's capabilities. He entered Tom's address via an on screen touch sensitive keyboard. Within a few seconds, the display brought up sort of a trip ticket from where we were, which Harry had indicated by a tap on the screen, right to the passenger drop off at the medical office building. Not only was it a neat trick, but it disguised that I had no clue where Tom's office really was in the maze of unfamiliar new streets in this alternative Reston. Harry, whose enthusiasm for these gadgets was just radiative, explained that if we were lost or wanted guidance, we could toggle on the LEO satellite ranging option – but there was a $1 charge per position fix. As we got off Route 7 and navigated through Reston, we all thanked Harry for the ride and all the interesting information. Pulling into the compact suburban medical center's passenger drop-off area, Harry wished us good luck. Just in case, I asked him for his business card. Harry wrote his home phone number on the back and told me I should come visit him some weekend... We could talk satellites. I stuffed the card in my back pocket, along with Hilary and Gib's numbers.

And with a handshake and a wave, Harry zoomed away leaving the three of us standing under the trees and the gray autumn clouds at the front door of the medical office

I had been to 100 times before, visiting my brother to say hi, and his partner to take care of my aging athlete's knees. This was the office that I had helped my brother move into when he opened his practice. But also the office which was inside a building I had never seen before.

Alone together for the first time since Hilary found us last night, we took a minute to replay the last 24 hours. It was tempting to dismiss Gib and Hilary – and Harry Lee – as just a few bit heads who moved to the country. Information age survivalists holed up with an arsenal of exotic gadgets. Ok, the satellite phone, e-mail and weather could easily be bogus. But what about Jennifer's talk with her dad? Harry's story sounded genuine. How could he have found the location of Tom's office from just the address if the CD-ROM were a fake?

But the overwhelming fact was that the major routes like Leesburg Pike were pretty much the way we knew them and the old Reston landmarks like Lake Anne were still here, but all the newer streets and buildings were completely different. And how to explain that neither AeroAstro nor I is in the Northern Virginia phone book? Maybe, opposite of Jennifer's father, I am alive in my world, but dead in this one. My brother is in for a shock in that case.

We agreed that whatever the explanation given we have no place else to go, no ID and no money, my brother was our best, and possibly only, shot. We walked in, found his suite via the directory and as we walked in, I told the receptionist I was a cousin of Tom's and was in the area and stopped by to say hello. If I really were dead, I didn't want him to freak and maybe call the police before I got him to see me. She buzzed him and lead us back to his office.

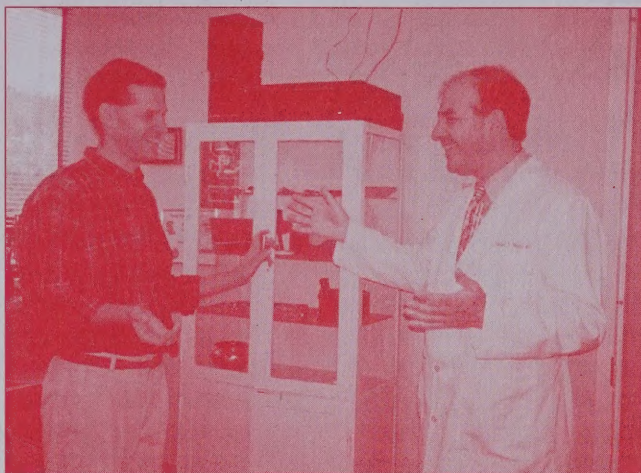
"Dr. Fleeter is in with a patient – he'll be with you in just a minute."

The 1st floor room was somewhat larger than the 3rd floor office that I remembered, but its contents were familiar. His diplomas and medical board certifications hung on the wall and our grandfather's delicate and antique examining instruments were neatly arranged in a glass case.

Tom rushed in dressed in his white lab coat over a button down blue shirt and club tie.

"Hey, Rick. I thought BJ said you were Sandy – she said my cousin was here. Launch get done early? Who are your friends?" Employing a strategy which helped me achieve near pinball wizard status on all the college boards, I tackled the easy one immediately. His question also provided me a handy test.

"You remember Jennifer and Har'el from the company?" In my world Tom came to most of our parties and met all the AeroAstro-nauts.



"Sorry. But how often do I show up in Oregon?"

I thought to myself, "I work in Oregon?"

"Anyway, nice to meet you, Jennifer, and... what was your name?"

"Har'el"

Tom nodded acknowledgment.

"Tom, we have something we need to talk over..."

A voice on his office intercom announced Mrs. Vanoker was ready to see him in room D.

"You're busy – you breaking for lunch soon?"

"Half an hour. Why don't you cross over to the hospital and I'll meet you in the cafeteria."

"Ok – see you over there."

Next issue:

- *Healthsat on steroids – worldwide health care delivery via microsatellites.*
- *Four kids, a Macintosh and the Kidpix of ground station applications.*
- *260 small payload launches per year... and rising.*
- *Is the world ready for two Rick Fleeters?*

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day. Balloons containing these sensors are sent up twice a day from points worldwide.

Orbital rents space on the their MicroLab platform to customers needing a turnkey space solution. In the case of MicroLab-1, the spacecraft is operated from their Dulles, Virginia headquarters, where the sensor tasks, received via Internet from NASA and UCAR, are converted to satellite commands, and uplinked via a remote tracking station in Fairmont, West Virginia. The resulting science data is distributed to partner organizations via Internet, or on magnetic tape.

Clementine survives deep freeze, phones home

Apparently, BMDO's Clementine spacecraft is not yet "lost and gone forever". The spacecraft responded to commands from NRL's Alexandria, Va. mission control center on April 10, marking the first contact since Clementine spun out of control last July. At the time of the incident, Clementine was en route to the near-earth asteroid Geographos, having just completed a lunar mapping mission. While it won't be possible for Clementine to complete the asteroid fly-by, mission officials expect to gain valuable insights from tracking the performance of the spacecraft subsystems. These systems enabled the spacecraft to survive months of extreme temperatures with almost no power. Such data will be quite useful for planning future missions using similar components.

Contacting the spinning Clementine has been tricky for controllers who must make do with the spacecraft's low gain omnidirectional antenna. By utilizing NASA's Deep Space Network, they were able to get a good deal of power, temperature, and pressure telemetry down from the spacecraft. As of May 11, a variety of Clementine's subsystems had powered up successfully, and commands had been sent to dump oxidizer in an effort to lower the spin rate. In addition, solar arrays were commanded to more favorable sun angle to produce more power for the spacecraft.

For those with World-Wide Web access, additional news is often available on the ISSO web site. This month, we take a quick look at Aercam and Inspector, two concepts for robotic TV space cameras.

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